Potential increase of flood hazards over Korea due to global warming

Eun-Soon Im[1], Ji-Hye Kwon[2], Byong-Ju Lee[1], and Sang-Ok Han[1]

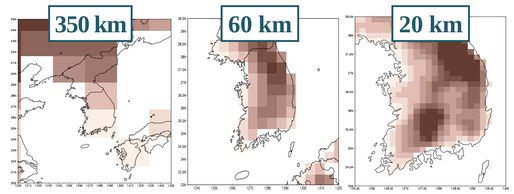
[1]National Institute of Meteorological Research, Korea Meteorological Administration, Korea / [2]Korea Infrastructure Safety & Technology Corporation , Korea

❑ Background

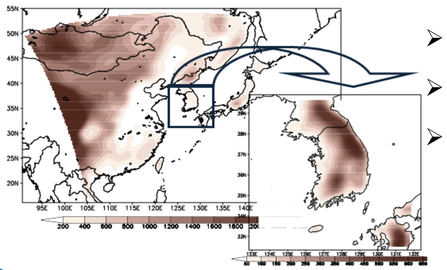
- Korea is regarded to be a highly *vulnerability region in response to global warming*, in particular for water resources.
- As Korea is exposed to *flood hazards* due to both nature and human factors, the modulation of hydrological cycle due to enhanced water holding capacity in warmer atmosphere can result in the complex and non-linear response in terms of mean as well as extreme precipitation changes.
- Since extremely heavy rainfall events mostly range from several hours to one day, *intensive examination of the sub-daily precipitation* are necessary to assess the accurate characteristics of precipitation extremes and future hydroclimatic response to global warming.

❑ Necessity of Dynamical Downscaling for the Korean Climate Simulation

- Korea is a representative region that can reveal the *limitation of the GCM simulations* since the territory is relatively small and has *complicated mountainous terrain.*
- For example, this figure clearly explain how the representation of topography depends critically on the model resolution. Low resolution GCM represents southern part of Korean as an ocean grid point. Unrealistic land-sea distribution could lead to lack of accuracy on the simulation.



❑ RegCM3 One-Way Double-Nested SUB-BATS System for Korea



- Resolution: Mother domain – 60km & Nested domain – 20km
- Initial & Boundary : ECHAM5/MPI-OM A1B(1.875) - IPCC AR4 participant model
- Integration Period : [Reference Scenario] 1971 - 2000 (30yr)

  & [Future Scenario] 2000 – 2100 (100yr)

❑ Generalized Extreme Value (GEV) Distribution

$$F(x) = \exp\left[-\left(1-\frac{\beta(x-x_0)}{\alpha}\right)^{1/\beta}\right]$$

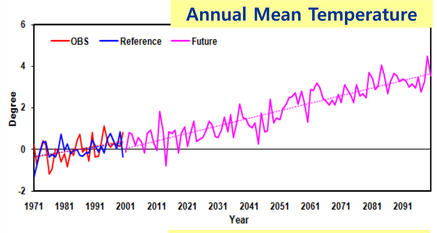
(Where, $\alpha > 0$: scale parameter,

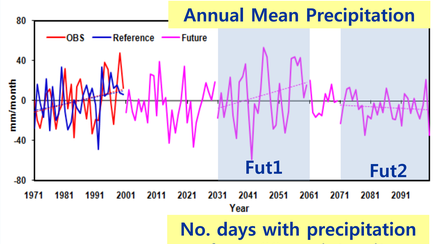
β : shape parameter,

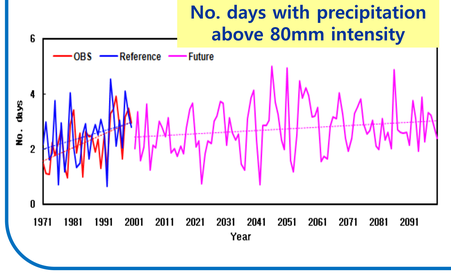
x_0 : location parameter)

- As the statistical analysis to derive well-fitted *intensity-duration-frequency (IDF)* curves, we applied the generalized extreme value (GEV) distribution which is computed from the *annual maxima values* occurring within a certain duration (e.g. 3-hour to 24-hour).
- The location parameter determines the mean while the scale parameter is proportional to the standard deviation. The type of GEV distribution are determined by the shape parameter, controlling the tails of the distribution

Change of Long-term Trend & Variability

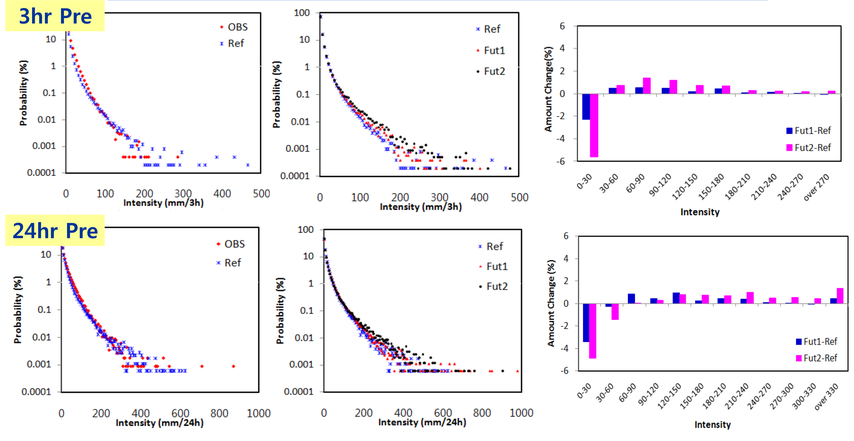






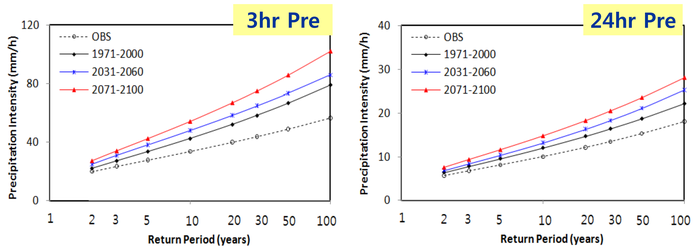
- The trends and variability of the simulated temperature and precipitation demonstrate remarkable similarity with those of the observations.
- The temperature is projected to continuously increase up to 4 ºC at the end of the twenty-first century. The *degree of warming is sharply accelerated* in the future, indicating a well-defined increasing trend.
- The projected change of precipitation is different, however. It is difficult to find any readily apparent trends in the precipitation evolution. It's rather mixed pattern.
- Although the annual precipitation does not show any relevant trend, the indices used to measure the *frequency and intensity of heavy precipitation show significantly increasing trends* (e.g. the number of days with precipitation above 80 mm intensity)

Frequency distribution of 3-hr & 24-hr precipitation



- The reference simulation (Ref) shows a *good agreement with observed distribution* except for an overestimation at the high intensity range above 200 mm/3hr and 300 mm/24hr, especially in case of 3-hour precipitation.
- By comparison of the simulations between the reference (Ref) and two future (Fut1 and Fut2) periods, *interestingly far future distribution seems to be more heavy precipitation* even though the anomalies of annual mean precipitation are mostly negative during the Fut2 period.
- Despite the fairly large differences in 30-year temporal evolution of annual mean like increasing trend for Fut1 and decreasing trend for Fut2, both change behaviors of 3-hour and 24-hour precipitation show a similar pattern and sign. *An enhancement of relatively high intensity precipitation and a reduction of weak intensity precipitation are discernible*.

Intensity-Duration-Frequency Curves



- The difference between the observed and Ref values becomes larger as the return period becomes longer. The IDF curves clearly impose the model deficiency to overestimate high-intensity heavy precipitation
- *The degree of reduction of return period becomes more pronounced in the late 21st century* as the greenhouse gas concentration is increased, which in line with the results of other studies.
- The fact that future values are systematically higher than their corresponding values in reference climate is certainly an indication *towards more intense heavy precipitation in the future warmer climate* over Korea.
- The intensity enhancement is more pronounced in 3-hour duration, which implies more vulnerability against flood hazards.

❑ Summary

- *The frequency and intensity of extreme precipitation* occurring in sub-daily and daily duration are continuously *increasing in response to global warming*, even without significant increase of total precipitation.
- *Significant reductions of return periods* are found across sub-daily and daily durations. Moreover, the degree of reduction of return period is mostly dominant in 3-hour precipitation extremes. It could bring substantial problem for the management of water resources. Therefore, reliable estimation of probabilities of extreme precipitation is particular concern for the purpose of designing water management and coping with climatic hazards such as floods and droughts.

❑ Acknowledgements

This work was supported by a grant (code No. 3100-3136-442) funded by the National Institute of Meteorological Research (NIMR), the Korea Meteorological Administration(KMA)